Fermilab

$\bar{p}$ Note #393

Effects of the Systematic Errors in Quadrupoles

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Effects of the Systematic Errors in Quadrupoles

In the accumulator, five types of small-aperture quadrupoles and four types of large-aperture quadrupoles are used and they are in four groups as far as the excitation currents are concerned.

	SQA	SQB	SQC	SQD	SQE	LQA	LQB	LQC	LQD
Group 1.		Q1f	Q3f		Q2d				
2.	Q4f &Q8f		Q6f						
3.	Q9d		Q7d	Q5d					
4.						Q10f	Q14f	Q12d &Q13d	Q11f

(f = horizontal focus; d = horizontal defocus)

Eighteen magnets in group 3 have individual shunts and their strength can be adjusted by as much as 1% or more. In other groups, all magnets share the same excitation currents and the systematic errors in their $\int G \cdot d\ell$ may lead to errors in the linear lattice functions. We are especially interested in the errors $\Delta\beta/\beta$ and $\Delta\eta$ (dispersion function) at A10, A20, etc., i.e., at the center of long straight sections. Because of the mirror symmetry of our lattice, α and η' are always zero at these points. (In the real accumulator, they are of course not exactly zero because of the symmetry-breaking random errors.)

I have evaluated the change $(\Delta\beta/\beta)$ and $\Delta\eta$ which are proportional to the fractional error ε of each type of quadrupoles:

$$\varepsilon \equiv (\Delta\int G \cdot d\ell)/(\int G \cdot d\ell)$$

<u>Group #1</u> Adjust the current so that $\int G \cdot d\ell$ of SQE(Q2) takes the correct value.

$$\frac{\ell_{eff}(SQB)}{\ell_{eff}(SQE)} \equiv \frac{25.2''}{51.64''}(1+\varepsilon_B); \quad \frac{\ell_{eff}(SQC)}{\ell_{eff}(SQE)} \equiv \frac{27.6''}{51.64''}(1+\varepsilon_C)$$

At A10,30,50:

$$\Delta\beta_x/\beta_x = -3.50\varepsilon_B - 4.45\varepsilon_C$$

$$\Delta\beta_y/\beta_y = 4.35\varepsilon_B + 4.09\varepsilon_C$$

$$\Delta\eta = 0.$$

At A20,40,60:

$$\Delta\beta_x/\beta_x = 0.34\varepsilon_B + 3.50\varepsilon_C$$

$$\Delta\beta_y/\beta_y = 0.69\varepsilon_B + 1.85\varepsilon_C$$

$$\Delta\eta = 0.$$

<u>Group #2</u> Adjust the current so that $\int G \cdot d\ell$ of SQC(Q6) takes the correct value.

$$\frac{\ell_{eff}(SQA)}{\ell_{eff}(SQC)} \equiv \frac{18''}{27.6''}(1+\varepsilon_A)$$

At A10,30,50: $\Delta\beta_x/\beta_x = 0.31\varepsilon_A$, $\Delta\beta_y/\beta_y = -3.00\varepsilon_A$, $\Delta\eta = -1.13\varepsilon_A$(meters)

At A20,40,60: $= 5.10\varepsilon_A$ $= -1.17\varepsilon_A$ $= -0.05\varepsilon_A$(meters)

<u>Group #4</u> Adjust the current so that $\int G \cdot d\ell$ of LQC(Q12 & Q13) takes the correct value.

$$\frac{\ell_{eff}(LQA)}{\ell_{eff}(LQC)} \equiv \frac{14.4''}{30.4''}(1+\varepsilon_A); \quad \frac{\ell_{eff}(LQB)}{\ell_{eff}(LQC)} \equiv \frac{25.3''}{30.4''}(1+\varepsilon_B); \quad \frac{\ell_{eff}(LQD)}{\ell_{eff}(LQC)} \equiv \frac{34.4''}{30.4''}(1+\varepsilon_D)$$

At A10,30,50:

$$\Delta\beta_x/\beta_x = 1.47\varepsilon_A + 0.24\varepsilon_B + 4.87\varepsilon_D$$

$$\Delta\beta_y/\beta_y = 0.24\varepsilon_A + 0.38\varepsilon_B + 2.01\varepsilon_D$$

$$\Delta\eta = -2.08\varepsilon_A - 21.50\varepsilon_B - 28.69\varepsilon_D \quad \text{(meters)}$$

At A20,40,60: $\Delta\beta_x/\beta_x = -0.43\varepsilon_A \;\; -3.03\varepsilon_B \;\; -5.70\varepsilon_D$

$\Delta\beta_y/\beta_y = -0.09\varepsilon_A \;\; +3.55\varepsilon_B \;\; +4.36\varepsilon_B$

$\Delta\eta = -6.13\varepsilon_A \;\; -31.10\varepsilon_B \;\; -54.79\varepsilon_D$ (in meters)